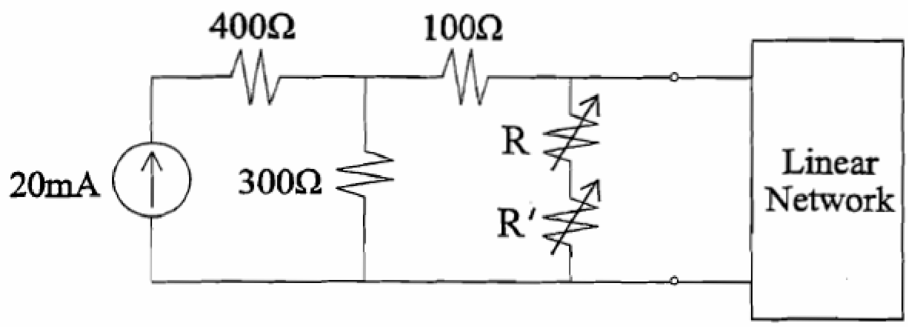
ECSE 200: Fundamentals of Electrical Engineering

Assignment 5

Winter 2006

Question 1

Consider the circuit below; the linear network is defined by $V_{OC} = 10V$ and $I_{SC} = 25mA$.



(a) Find the value of resistance R that yields maximum power transfer to R, if $R' = 50\Omega$.

(b) Assume that R is fixed at the value found in (a), but now resistance R′ can be varied. Find the value (non-negative!) of R′ that maximizes the heat dissipated in R.

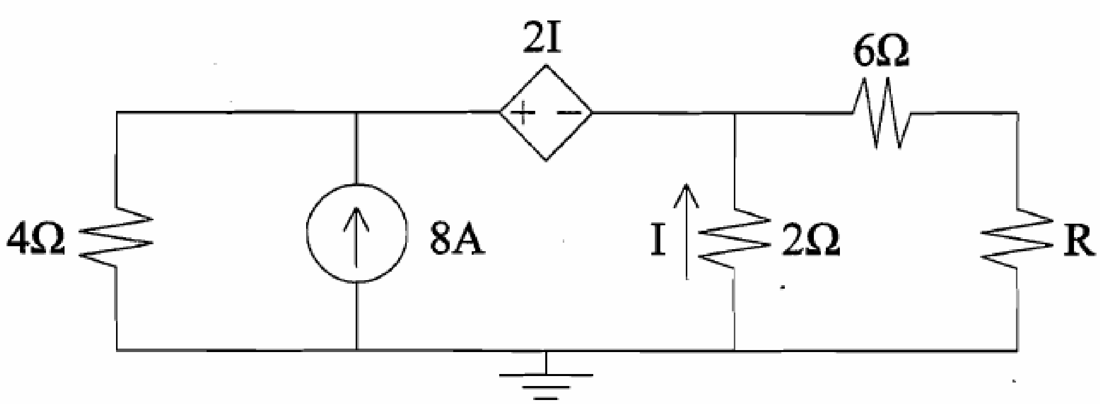
(c) Finally, assume both R and R′ can be varied (to independent non-negative values). Find the values of R and R′ that yield maximum power transfer to R.

Question 2

Consider the linear circuit provided below and answer the following questions:

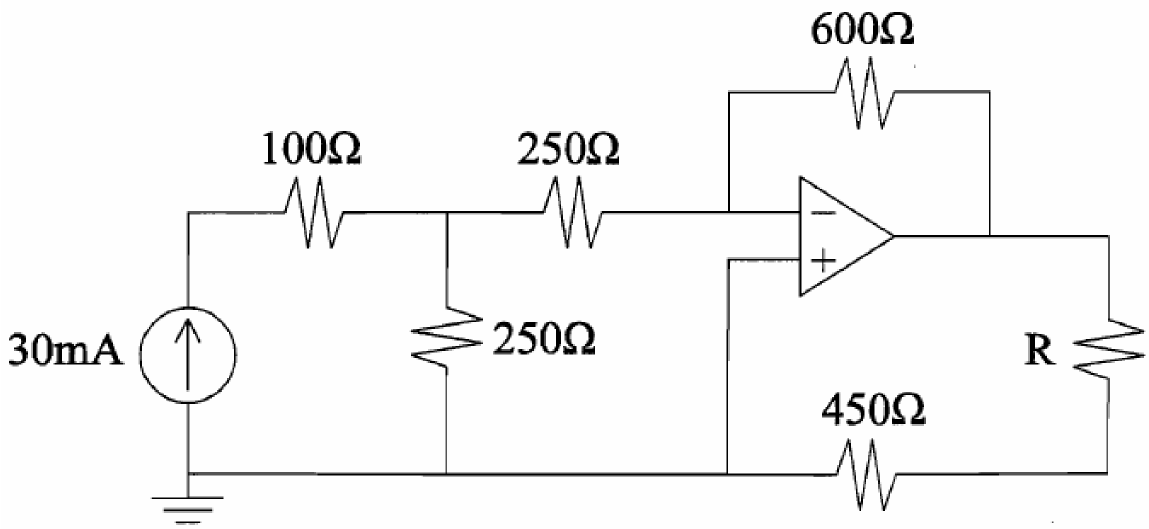
(a) Determine the value of R which yields maximum heat dissipation in this resistor.

(b) Find the amount of energy delivered to R per second, for this value of R.



Question 3

Consider the linear ideal op-amp circuit shown and answer the following questions:



(a) Determine the value of R which yields maximum power transfer to this resistor.

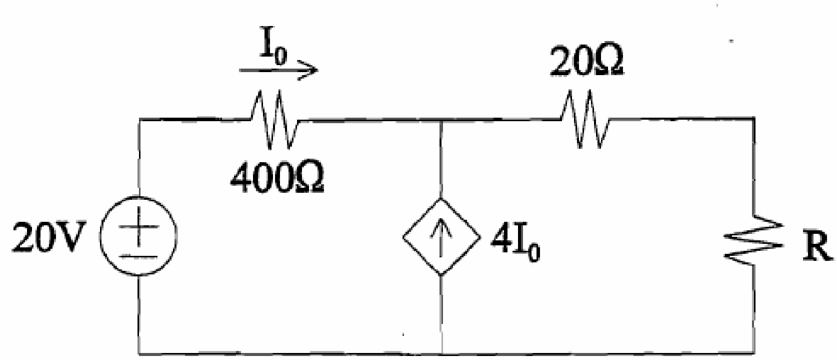
(b) Find the power delivered to the circuit through the op-amp for this value of R.

Question 4

Consider the linear circuit provided below and answer the following questions:

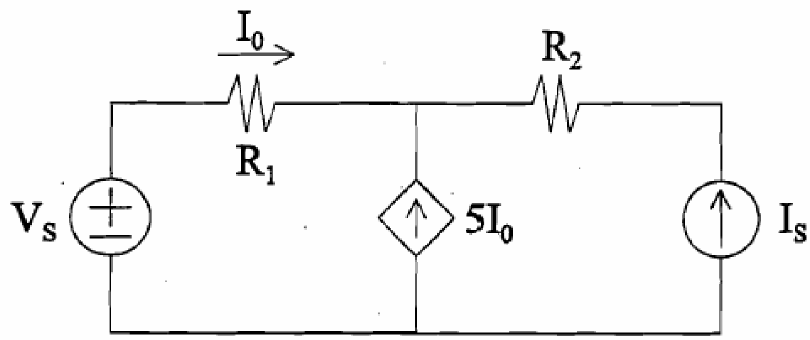
(a) Determine the value of R which yields maximum heat dissipation in this resistor. Also: Find the amount of energy delivered to R per second, for this value of R.

(b) Determine the value of R which causes the two sources to supply identical amounts of power to the circuit.



Question 5

Draw (*clearly!*) the circuits that you would need to use to analyze the circuit provided below using linear superposition. (You are not required to solve these circuits.)



Question 6

You are an engineer at the *Bright Ideas Electric Company*, and your boss has just given you the task of designing a maximum output ohmic bulb for a new electric light battery. The battery is linear; specifications are listed below. Assume light output is proportional to the electrical power delivered to the bulb filament, and answer the questions below:

Battery Specifications: open-circuit output voltage = 12 V_{DC} ;
open-circuit internal losses = 25 mW ;
short-circuit output current = 3⅓ A_{DC} .

(a) Find the power that would be consumed by the optimal bulb if it were connected to this new battery using wires and contacts of negligible resistance.

(b) How would the power output of the battery change (increase / decrease / no change) from that in part (a) if the bulb were connected to the battery with resistive wires? (Briefly explain the reasoning behind your answer.)

(c) Assume that you are also required to provide a temporary solution to this maximum lighting problem using standard 60W (12V_{DC}) light bulbs. Find an interconnection of these bulbs which provides maximal light output when connected to the battery. Assume the bulbs are ohmic and the connecting wires are of negligible resistance.

Question 7

Design a resistive heating element that will produce maximal heat when connected to the industrial battery described below. The heating element must be constructed from a standard heater coil wire, which is ohmic and rated at 2Ω/m. The secondary design objective is to minimize material cost, by using as little heater coil wire as possible.

Battery Specifications: open-circuit output voltage = $120V_{DC}$;
open-circuit internal losses = 160 mW;
short-circuit output current = $15A_{DC}$.

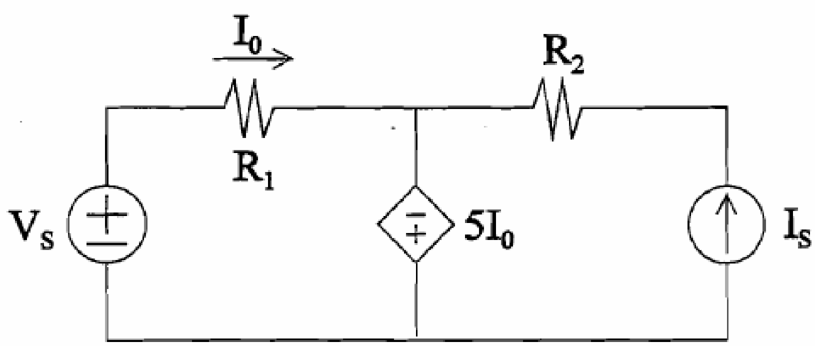
(a) Calculate how much heater coil wire is required to construct the heater element.

(b) Calculate the heat output of the heater element when it is connected to the battery.

(c) Re-calculate how much heater coil wire would be required, if the heater coil wire was only rated for a maximum operating current of $2.5A_{DC}$, for safety reasons.

Question 8

Assume that you are required to analyze the circuit provided below to find the current labelled I_0. Draw the circuit(s) that would be necessary for the analysis if you were to use *linear superposition*. Do not solve the circuit(s), but clearly show what variable(s) should be solved for in the superposition circuit(s) to find I_0 in the original circuit.



Question 9

Clearly explain how to measure an exact Thevenin equivalent circuit representation for a practical battery, using only an ideal ammeter and a 10kΩ resistor. You may assume that the battery is linear and fully charged. Express your solution clearly and concisely in terms of specific current measurements. Please note that you are not allowed to use any other equipment or data in your proposed solution, except for that provided above.

Also: Determine the worst case underestimate and the worst case overestimate for the value of the Thevenin resistance that could be found using your approach, if the 10kΩ resistor had a tolerance of ±10%, and the ammeter was subject to a ±5% error per measurement. Assume $0 < R_{INT} < 95k\Omega$ for this battery, and express your answers in terms of the exact current(s) used to answer the question above.

Note: Please feel free to use circuit diagrams to illustrate and clarify your explanation.

Question 11

A model of an electronic circuit is shown in Figure 1. The goal is to select *R* in order to deliver maximum power to a load resistor *R*. The resistor is constrained so that $0 \le R \le 5\ \Omega$. Find *R* that will result in the maximum power being absorbed by *R* and the magnitude of that power.

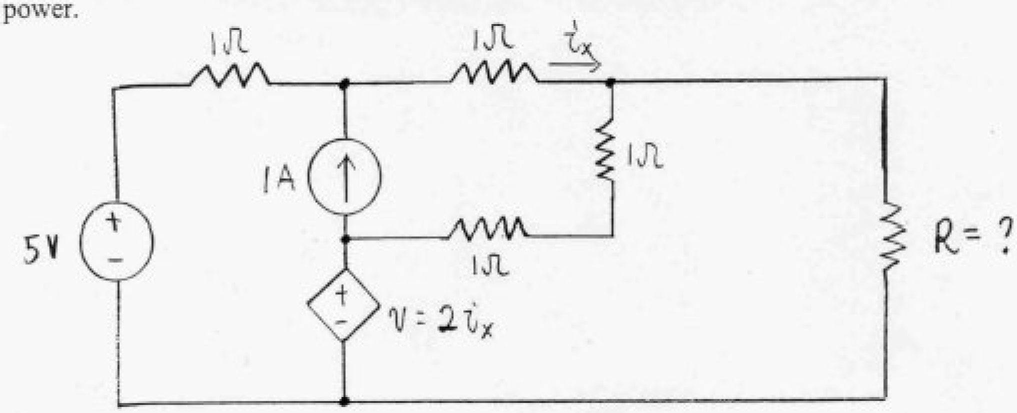


Figure 1

Question 12

Consider the circuit shown in Figure 2. This circuit is called a bridge amplifier. The operational amplifier and resistors R_5 and R_6 are used to amplify the output of the bridge. The operational amplifier in Figure 2 has been modeled as an ideal amplifier. Determine the output voltage, v_o in terms of the source voltage, v_s.

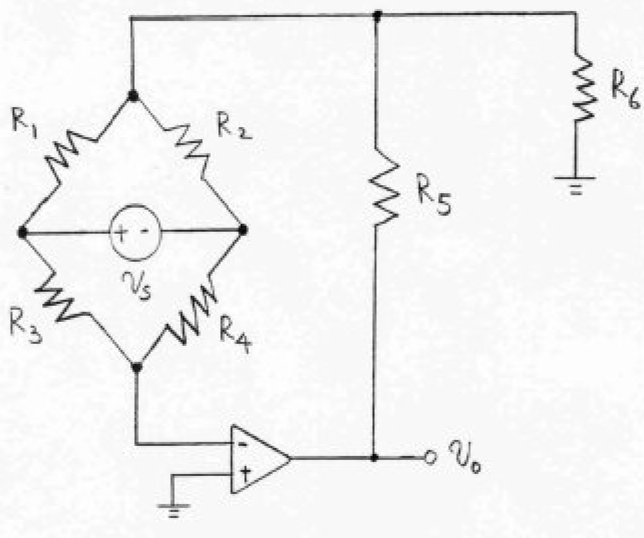
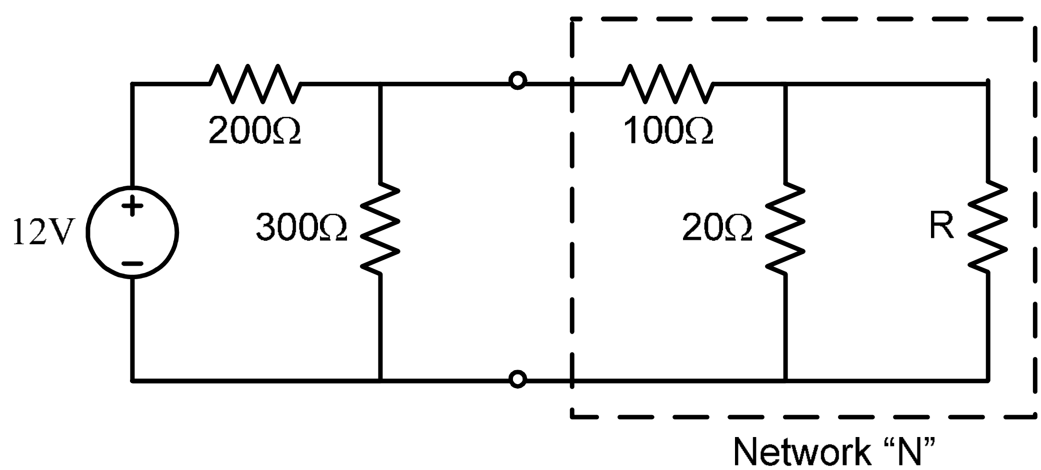


Figure 2

Question 13

Find the value of the resistor labeled "R", which will cause the largest amount of heat to be dissipated within the network "N", during each hour of circuit operation.



Question 14

Clearly demonstrate the use of "Linear Superposition" to analyze the circuit shown below, to solve for the energy supplied by the current source during each minute.